APPENDIX C

HYDROLOGY AND FLOODING ANALYSIS

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EAST SUNNYVALE ITR PROJECT
HYDROLOGY AND WATER QUALITY

This report provides a discussion of local hydrology pertinent to the East Sunnyvale ITR Project, both for the General Plan Amendment on the entire site, as well as two specific development projects. After describing the hydrologic setting and existing conditions, project impacts and mitigation are described.

1.0 Existing Conditions

1.1 *Regional Setting*

Sunnyvale is located within the part of the Santa Clara Valley that lies between the eastern flank of the Santa Cruz Mountains and San Francisco Bay (Figure 1). Sunnyvale lies roughly 7 miles northwest of downtown San Jose at the south end of San Francisco Bay.

Figure 1: Sunnyvale Location

1.1.1 ***Watershed.*** The project site sits between Sunnyvale East Channel and Calabazas Creek within the Santa Clara Valley Water District's "West Valley Watershed". This watershed, the smallest in the county, drains about 85 square miles of land area directly to San Francisco Bay via a number of relatively small creeks and their tributaries. While many creeks remain in their natural state in the foothills, most of the valley floor has been urbanized with a heavily channelized drainage system.

1.1.2 ***Project Location.*** The East Sunnyvale ITR project area is located in east Sunnyvale, generally bounded by Duane Avenue on the north side, Stewart Avenue on the south side, Wolfe Road on the west side and San Xavier on the east side. Sunnyvale High School is located on the western boundary of the project site. The nearest major thoroughfares are U.S. Highway 101 (Bayshore Freeway) to the north and Lawrence Expressway to the east.

1.1.3 ***Geology.*** The project area sits atop broad alluvial fans that were formed as streams emerged from the eastern Santa Cruz Mountains onto the Santa Clara Valley floor and deposited unconsolidated materials as their slopes flattened. Streambed deposits and alluvial fans generally slope toward San Francisco Bay to the north. The alluvial nature of deposition tends to leave "perched" channels, where flood flows in excess of channel capacity tend to leave a channel never to return. The resulting shallow overland release of flood waters is characteristic of the valley floor in Sunnyvale and the source of significant regulatory flood hazard areas.

Basin and shallow marine deposits in the flat interior baylands areas adjacent to Highway 101 are predominantly composed of fine grained deposits, silts and clay. These materials and much of the altered fill upon which development historically took place are relatively poor draining soils. Heavy urbanization also contributes to relatively high runoff rates despite the flat topography.

Historic land subsidence resulting from overdraft pumping of groundwater has exacerbated drainage problems created by the naturally flat topography, and placed portions of northern Sunnyvale below average sea level. Artificial levees and floodwalls in the baylands and upstream along creeks to higher ground keep high San Francisco Bay tides out of urban areas, and large storm water pump stations are needed to discharge interior runoff trapped behind levees and floodwalls.

1.1.4 ***Climate.*** The project area's climate is moderate – some would say ideal – with an average summertime high temperature of 70°F and an average winter low temperature of 53° F. Mean annual precipitation on this part of the valley floor in Sunnyvale is about 14 inches. Annual evapotranspiration over the watershed is approximately 49 inches, thereby resulting in an annual moisture deficit.[1]

Roughly 90 percent of the region's annual precipitation falls from November through March. Year-to-year rainfall varies greatly, and droughts of various durations are common. Over the period of record of 129 years for San Jose rainfall, Santa Clara County has had seven major droughts, and several relatively wet periods. The driest and wettest two-year cases over the period of record have been 1976-1977 and 1982-1983 respectively. Precipitation has generally been above average in the County since the 1990's. Precipitation in the form of snow, ice or hail is incredibly rare.

[1] Source: California Irrigation Management Information System (DWR) data.

1.1.5 ***Land Use.*** The project site is currently zoned for industrial uses and is occupied by that type of land use. Figure 2 provides an aerial view of the project area. With the existing build out, approximately 17 percent is unpaved open space as shown below, leaving 83 percent as impermeable surface.

Figure 2: Existing Conditions, Shaded Area is Open Space

1.2 *Drainage and Flooding*

Site topography is relatively flat, but there is positive slope to the north and to the east. The existing storm drainage system (shown in Figure 3) funnels runoff to Duane Avenue and Lawrence Expressway, where a 42-inch diameter storm drain leads to a 72-inch diameter storm drain in Lakeside Drive. The storm drains outfall to Calabazas Creek. (Across from the outfall is the Lakeside Pump Station owned by the City of Santa Clara.)

The Santa Clara Valley Water District prepared an interior drainage study encompassing the project area for the *Calabazas Creek Flood Control Project: Guadalupe Slough to Arques Avenue* (Schaaf & Wheeler, 2002). That study found no significant residual drainage problems in the project area and is used herein as a basis for impact assessment.

During extreme runoff events, the northwesterly portion of the project area is subject to shallow overland flooding from Sunnyvale East Channel overflow. The currently effective Flood Insurance Rate Map for Sunnyvale (shown as Figure 4) indicates a regulatory Zone AO with an average depth of 1.5 feet. In addition to the regulatory flood plain, Figure 4 shows the Santa Clara Valley Water District's "daylight" limit of flooding; that is, flooding with depths between zero and one foot.

Figure 3: Existing Storm Drain System

Figure 4: Regulatory Flood Hazard Zones (Zone AO, depth 1.5 feet and Shaded X, depth <1 foot)

2.0 Project Impacts

This section examines the general and specific impacts to the project area's hydrology from the General Plan Amendment and site specific projects using current planning and regulatory climates to define those impacts. Most particularly, project impacts to storm drainage and potential flooding are quantified using information developed for FEMA as a basis.

2.1 *General Hydrologic Impacts Due to Development*

Land previously vacant, fallow, or in agricultural production converted to urban uses (residential, commercial, industrial, institutional) contain more hardscaped area (building footprints, paving, sidewalks, plazas, etc.) than currently rural areas. These hard surfaces are more impermeable and result in less soil infiltration of rainfall and surface runoff. Moreover, urbanized areas tend to have more developed and efficient drainage systems than open areas, with storm runoff often conveyed in underground pipes. Storm water runs off more quickly from a developed area than an open area, all other conditions equal.

2.2 *East Sunnyvale ITR Project Synopsis*

The proposed General Plan designation would be ITR, or Industrial-to-Residential. The ITR combining district was created in 1993 to specifically identify commercial and industrial areas appropriate for transition to residential uses. An ITR designation on these sites allows for the continuation or expansion of existing industrial and commercial uses as well as the construction of new residential housing at various densities. Proposed residential conversion on this site ranges from R-2 low/medium density housing at 10 to 12 dwelling units per acre to R-4 high density residential development at 25 to 36 dwelling units per acre. Figure 5 shows the proposed GPA land use diagram.

2.2.1 Changes at Build-Out. The proposed General Plan Amendment is evaluating a change to a designation of Industrial to Residential (ITR). According to the zoning code of the City of Sunnyvale, any residential zoning must have a minimum of 20 percent of the total area landscaped. For example, Medium Density (14-27 units per acre) must landscape the greater of 20 percent of the gross acreage or the percentage yielded from landscaping 425 square feet per unit. Therefore, regardless of which is greater, the minimum landscaping that maximum build out will produce will be twenty percent. Note that under existing land uses, only 17 percent of the site is open or landscaped.

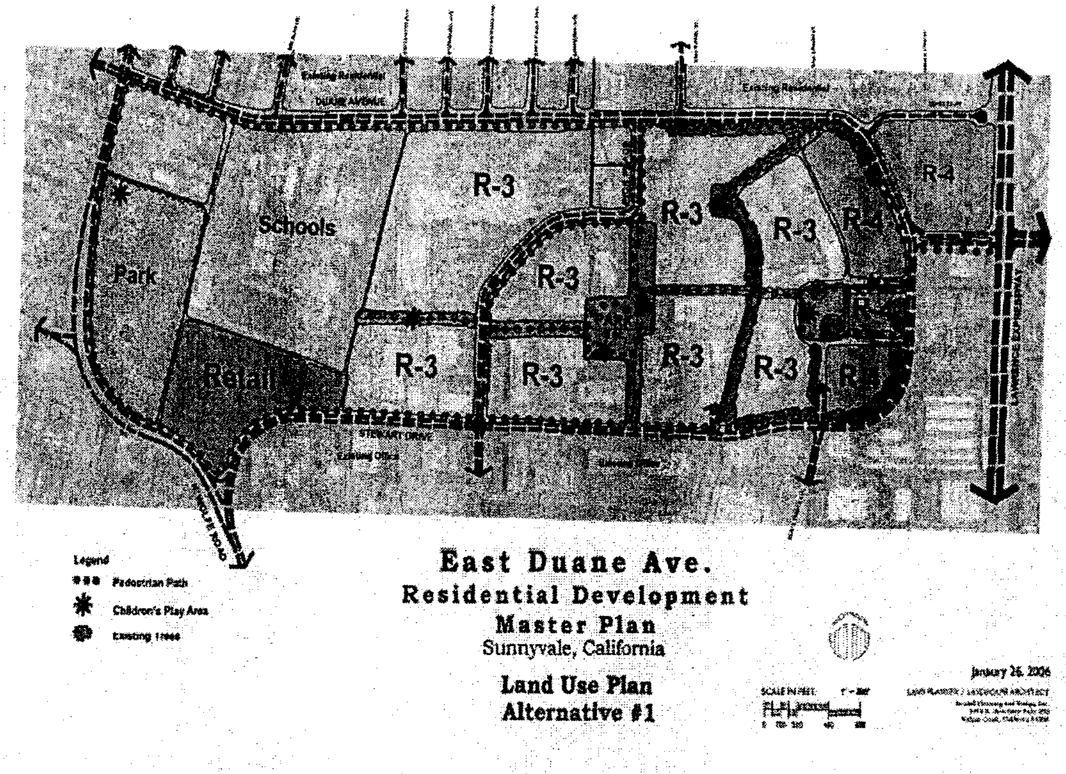


Figure 5: Proposed GPA Land Use Diagram

2.2.2 Specific Initial Development Projects. In addition to the General Plan Amendment, this project examines two specific development projects; one at the 14 acre AMD property, another at the Taylor Woodrow site.

A 219 unit townhouse development is proposed for the AMD property and is conceptually shown in Figure 6. The R-3 units (16 du/ac) would be three story, two to four bedroom residencies (some with den) ranging from 1,230 to 2,050 interior square feet. All units will have a two car garage. On Figure 5, this development project is located immediately east of Pick Place and is designated as R-3.

Conceptual plans for the Taylor-Woodrow development project on the northeast corner of the ITR site are shown as Figure 7. This project proposes a total of 304 units – consisting of a mix of condo/flats and townhouses roughly five stories in height. The site is approximately 7.3 acres and the breakdown of the unit types is shown on Figure 7. On Figure 5, this development project is the roughly triangular area bound by Duane Court, Lawrence Expressway, and East Julian Avenue; labeled as R-4, high density.

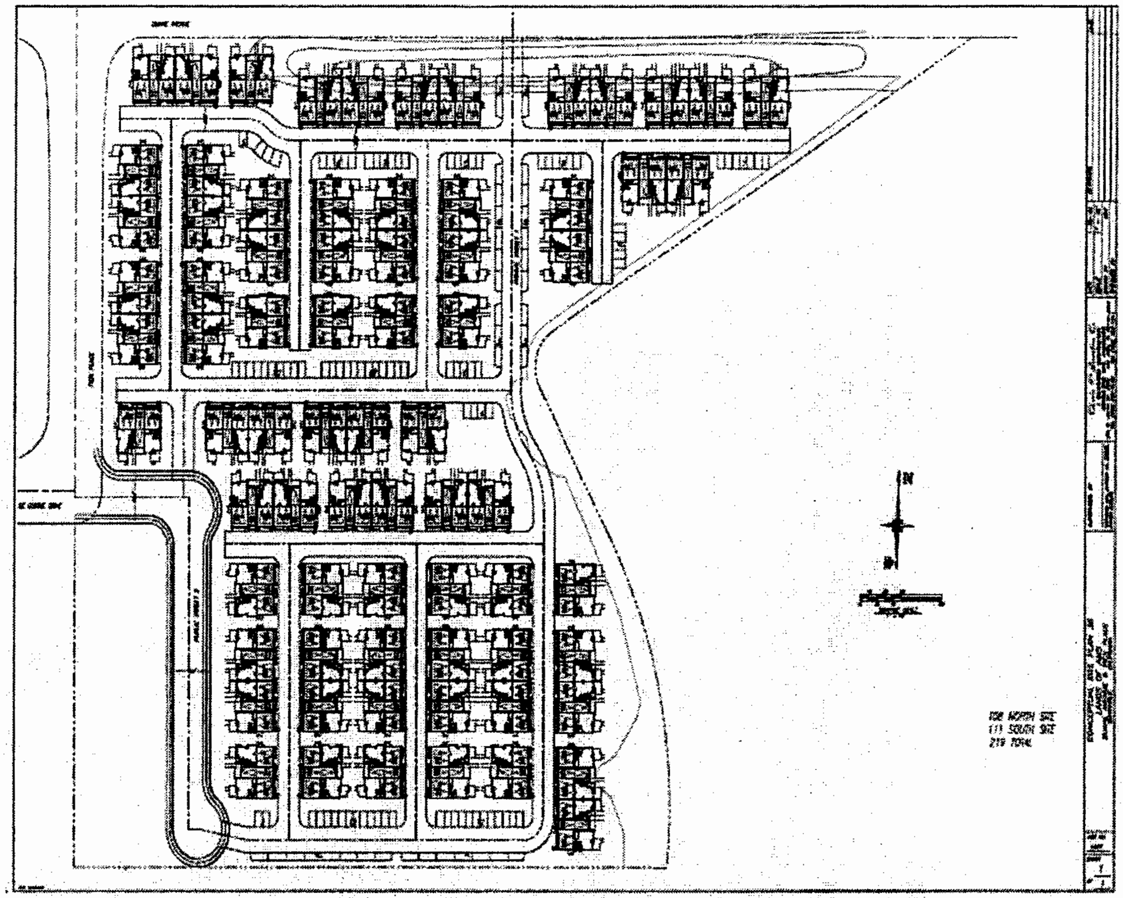
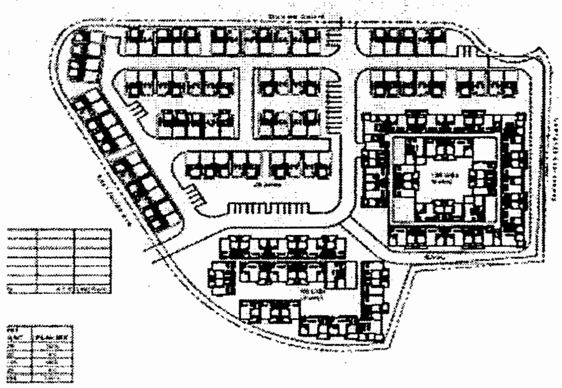


Figure 6: Proposed Townhome Development on AMD Site.



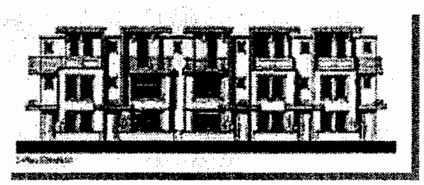


Figure 7: Taylor-Woodrow Project

2.3 *Project Impacts to Hydrology*

A hydrology or water quality impact is considered significant if the plan would:

- Violate any water quality standards or waste discharge requirements;
- Degrade or deplete groundwater resources or interfere with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table;
- Alter existing drainage patterns, including streams and rivers, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding inside or outside of the plan area;
- Alter existing drainage patterns, including streams and rivers in a manner that would result in significant erosion inside or outside of the plan area;
- Provide substantial additional sources of polluted runoff or otherwise substantially degrade surface or groundwater quality;
- Place structures within a 100-year flood hazard area that impede or redirect flood flows;
- Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam; or
- Expose people or structures to inundation by seiche, tsunami, or mudflow.

Each of these potential hydrology impacts is investigated below, and if appropriate, mitigation is proposed.

2.3.1 *Water Quality Standards*

> A hydrology and water quality impact is considered significant if the plan would violate any water quality standards or waste discharge requirements.

Development within the Plan Area is subject to the ordinances and policies of the City of Sunnyvale, Santa Clara County and the United States, and specific permit conditions. These ordinances, policies and conditions set forth water quality standards and conditions for the discharge of waste in compliance with the City's National Pollutant Discharge E System (NPDES) permit as overseen by the San Francisco Regional Water Quality Control Board. According to the City of Sunnyvale:[2]

> "The City of Sunnyvale is one of the 15 co-permittees under a regional municipal stormwater permit for the northern portion of the Santa Clara County, Order No. 01-024 and revised Order No. 01-019 issued by the Regional Water Quality Control Board (RWQCB) for Region 2. This permit regulates discharges from municipal separate storm drain systems into waterways under each of the co-permitee's jurisdiction within the Santa Clara Basin.
>
> "Each Co-permitee has developed an Urban Runoff Management Plan (URMP) to reduce, control, or otherwise address pollutant sources in discharges to the storm drain system. Departments within the City of Sunnyvale have adopted Best Management Practices (BMPs) and Standard Operating Procedures (SOPs) to reduce the presence of pollutants in stormwater discharges to the maximum extent practicable.
>
> "The Sunnyvale URMP focuses on prevention of illicit connection/illegal dumping, quality of industrial and commercial discharges, and minimizing impacts from new development and construction activities. The City implements BMPs for maintaining street and roads, storm drains, and water utilities, and preventing stormwater pollution. The City also provides public education and outreach activities related to the prevention of discharges of pollutants such as pesticides, copper, mercury, and other wastes that may have an impact on water quality."

Plan Area development must conform to all promulgated water quality standards and waste discharge requirements, so this impact is deemed to be less than significant.

2.3.2 *Degradation of Groundwater Resources*

> A hydrology and water quality impact is considered significant if the plan would degrade or deplete groundwater resources or interfere with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table.

The net result of GPA changes is to *reduce* the amount of impermeable surface within the project area. Therefore, there is no significant adverse impact to local groundwater recharge. Sunnyvale receives its drinking water from outside of the city. The conversion of current industrial and commercial uses to residential uses might increase the site's potable water consumption, but this increase in demand caused by a handful of new units within the entirety of Sunnyvale and Santa Clara County. New groundwater water wells and additional water supply deliveries are not required.

[2] City of Sunnyvale Department of Public Works. (www.sunnyvale.ca.gov)

2.3.3 *Induced Flooding Inside or Outside of Plan Area*

> A hydrology and water quality impact is considered significant if the plan would alter existing drainage patterns, including streams and rivers, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding inside or outside of the plan area.

The GPA shown in Figure 5 respects the existing drainage patterns formed by streets and storm drains. Therefore there would be no change in hydrologic parameters associated with land forms, such as hydraulic length, slope, and time of concentration. Coupled with land uses after ITR that are slightly less intensive than current land uses, whereby the ultimately proposed conversion of land use would not lead to an increase in the percentage of impermeable ground cover, the GPA would not substantially increase the rate of amount of surface runoff. (In fact, runoff may decrease.) Potential project impacts are therefore limited to scenarios whereby individual site develop within existing open space areas before the percentage of hardscape elsewhere in the GPA is commensurately reduced.

2.3.3.1 Basis of Impact Analysis. Impact analysis is based upon the interior drainage study prepared for the Santa Clara Valley Water District's Calabazas Creek project. (Schaaf & Wheeler, 2002) For that study, two basic methods – Rational Method and unit hydrographs – were used to compare interior drainage basin runoff against the coincident stage in Calabazas Creek for the one-percent design event. That study has been modified as described herein to examine impacts due to individual developments within the project area.

Precipitation

One-percent design rainfall depths and temporal patterns match the Santa Clara Valley Water District's hydrologic model for the Calabazas Creek watershed. This methodology generates local runoff within the interior areas that is consistent with the timing of the flood wave in Calabazas Creek.

Direct Runoff

Runoff from the project site and surrounding areas is estimated using a unit hydrograph convolution with the design hyetograph discussed in the previous paragraph. The SCS synthetic unit hydrograph is used. This procedure requires a single parameter, the basin lag. Based on the SCS definition of their unit hydrograph (attached), the basin lag may also be approximated as 0.6 t_c, where t_c is the time of concentration.

Estimates of basin times of concentration are based on Santa Clara County methodology (ref: *County of Santa Clara Drainage Manual*, March 1966; updated 2005 in draft form). Tributary drainage areas, land use, and runoff coefficients have been estimated using the City of Sunnyvale's storm drain block maps. The Rational Method for discharge estimation is used to obtain each basin's time of concentration, and by extension, its lag time. This is a lumped parameter estimator for peak discharge based on the following equation:

$$Q = CiA$$

where C is a runoff coefficient dependent on land use; i is the design rainfall intensity (inches per hour for a return period of T years, and a duration equal to the time of concentration, t_{cj}; and A is the drainage area of the basin in acres.

Rainfall intensity is based on Santa Clara Valley Water District methodology (ref: *Santa Clara Valley Water District Hydrology Procedures*, December 1998). Specifically, the rainfall intensity was determined using the Return Period-Duration-Specific (TDS) Regional Equation, using a mean annual precipitation of 14 inches. It is important to note that the Rational Method is used only to estimate basin lag, but not to produce hydrographs for further analysis. The District's Calabazas Watershed hyetograph does not appear to be statistically balanced, and the use of the TDS equations seems to produce higher peak discharge estimates. In this respect, the estimation of basin lag values may be somewhat conservative.

Basin times of concentration are calculated on spreadsheets presented in the detailed section of each interior drainage area. Following the Drainage Manual's method, the Izzard formula is used to estimate the initial inlet time:

$$T_o = \frac{41cL_o^{1/3}}{S_o^{1/3}(Ci)^{2/3}}$$

where T_o is the time in minutes required for overland flow to the first inlet; c is a retardance coefficient (0.007 for asphalt); L_o is the length of overland flow (back property line to gutter); S_o is the slope toward the gutter (ft/ft); C is the runoff coefficient; and i is the rainfall intensity (in/hr), which is a function of T_o. Iterative solutions are necessary to obtain the initial time of concentration.

The Rational Method combines individual drainage basins and "routes" flow through the main storm drain system to the basin outlet. Travel times in the storm drain system are based on a weighted average (by discharge) of full flow pipe velocity and street flow velocity over the length of travel.

Runoff Coefficients

Runoff coefficients for impact analysis are derived from draft *Santa Clara County Drainage Manual*. (Schaaf & Wheeler, 2005) These are reproduced here as Table 1.

Table 1: Runoff Coefficients

Land Use	C for Soil Type		
	B	C	D
Low Density Residential	0.30	0.40	0.45
Medium Density Residential	0.50	0.55	0.60
High Density Residential	0.70	0.70	0.75
Commercial	0.80	0.80	0.80
Industrial	0.70	0.75	0.75
Parks	0.20	0.30	0.35
Agricultural	0.15	0.35	0.40
Urban Open Space	0.10	0.35	0.45
Shrub Land	0.10	0.20	0.30

Based on Soil Conservation Service (NRCS) soil mapping for Santa Clara County, the project site is underlain by Castro Clay and Castro Silty Clay. Both soil types are categorized as SCS hydrologic soil type "D", which is a poorly draining soil prone to relatively high runoff rates. Table 1 confirms that a general conversion from a commercial/industrial mix to residential would not increase the runoff coefficient.

Hydrograph Calculation

Basin lag as determined from the time of concentration is used to produce an SCS synthetic hydrograph. Direct runoff is equivalent to precipitation in excess of the soil's infiltration capacity. This is based on soil type, land use, cover, and antecedent moisture conditions (i.e. how saturated the soil is at the beginning of the storm event). This analysis uses the Soil Conservation Service (SCS) Curve Number methodology.

The SCS Curve Number for pervious area with an Antecedent Moisture Condition of II½ (open space over D type soil = 94) is used with the estimated percent of impervious area within each basin. Using an AMC of II½ calibrates well to one-percent peak discharges from frequency analyses of stream flow records in the South Bay.

Storage Routing

Kinematic wave routines available in HEC-1 are used to route flows down streets (Manning's "n" = 0.020) or in storm drain pipes (n = 0.013). Runoff hydrographs at each outfall are compared to the stage in Calabazas Creek to determine which portion of the hydrograph is discharged into the creek, and which portion of the hydrograph is in excess of outfall capacity.

2.3.3.2 AMD Site. Treated as a separate development, the proposed 219 unit townhome project at the AMD site would increase the runoff coefficient of the area tributary to the 54-inch diameter storm drain system in Duane Court. On the 14 acre site itself, the estimated runoff coefficient from Table 1 would change from 0.45 to 0.75, assuming the highest (i.e. most dense) residential usage. The effect of this increase in impermeable surface has been examined using the interior drainage model described herein. Using a weighted runoff coefficient for existing and proposed land uses (assuming the AMD site develops prior to any other land use changes), the estimated weighted runoff coefficient increases from 0.55 to 0.75 for the area tributary to the existing 54-inch storm drain at Duane Avenue near AMD. Table 2 lists the impacts of this change in runoff coefficient.

Table 2: Impact to Local Runoff from AMD Site Development

	Peak Runoff (cfs)			
	10-year		100-year	
Location	**Existing**	**With AMD**	**Existing**	**With AMD**
Duane Avenue	108	111	159	163
Lawrence Expressway	205	207	313	317
Lakeside Drive	225	227	347	351

Increases in estimated peak runoff range from one percent to three percent, which would impact street flow depths as summarized by Table 3. The relative potential increase (0.01 foot) is not considered significant. Storm drain capacities and street flow depths are based on available topography used in the FEMA interior drainage analysis, and City of Sunnyvale Standard Details for Public Works Construction.

Table 3: Estimated Street Flow Depths

	Street	Street	Pipe	Pipe	Street Flow (cfs)				Street Flow Depth† (foot)			
	R.O.W.	Slope	Dia.	Cap.	10-year		100-year		10-year		100-year	
Location	**(feet)**	**(ft/ft)**	**(in)**	**(cfs)**	**Exist.**	**AMD**	**Exist.**	**AMD**	**Exist.**	**AMD**	**Exist.**	**AMD**
Duane	66	.001	54	60	48	51	99	103	0.31	0.32	0.54	0.55
Lawrence	134	.002	72	200	0	0	113	117	n/a	n/a	0.52	0.53
Lakeside	66	.001	72	130	95	97	217	221	0.53	0.54	0.83	0.84

†Above Top of Curb

The Interior Drainage Study hydrologic model has been used to investigate the potential impact of AMD development upon the discharge hydrograph to Calabazas Creek at the Highway 101 outfall. At this location 1.12 square miles drains to the creek. The net effect of AMD development is to increase the net percentage of impervious area tributary to the outfall from 75 to 76. This has no numerical effect on the estimated 100-year discharge hydrograph and therefore, there would be no impact to Calabazas Creek during extreme runoff events should the AMD site develop prior to other land use conversion in the project area. Figure 8 shows the 100-year discharge hydrograph at the Highway 101 outfall (Figure 9).

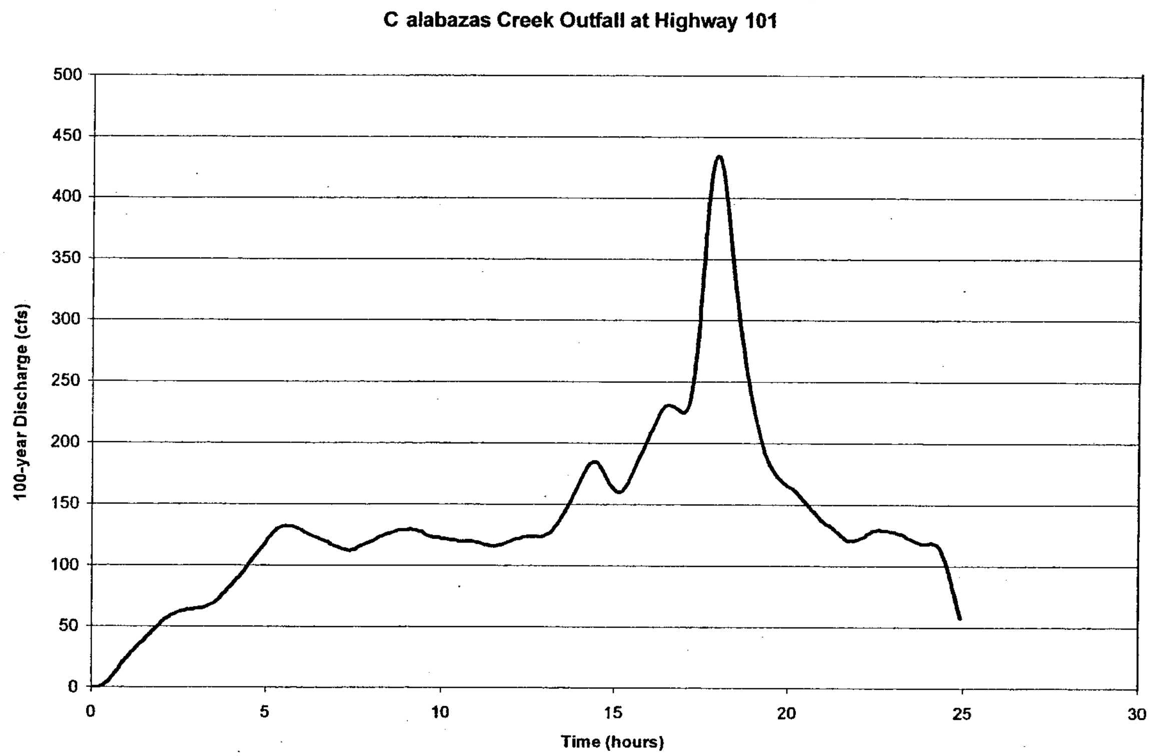


Figure 8: 100-year Discharge Hydrograph to Calabazas Creek at Highway 101 Outfall

2.3.3.3 Taylor-Woodrow Project. If the Taylor-Woodrow Project were to move forward irrespective of other redevelopment, its site would be converted from industrial development (C=0.75) to R-4 high density residential development (C=0.75) so any impact to storm runoff would be insignificant.

2.3.3.4 Flooding Outside the Project Area. Since the 100-year discharge hydrograph to Calabazas Creed remains unchanged (Figure 8), the proposed Sunnyvale ITR Project would not change flood risks outside of the project area.

2.3.4 *Induced Stream Erosion Inside or Outside of Plan Area*

A hydrology and water quality impact is considered significant if the plan would alter existing drainage patterns, including streams and rivers, in a manner that would result in significant erosion inside or outside the plan area.

Development in or near a natural floodplain has the potential the change that floodplain by increasing stream discharges (relative to the undeveloped state) and affecting the balance of sediment transport so that bed or bank erosion within the stream begins or is worsened. However as described herein, the conversion of industrial use to high density residential use has very little impact on discharge to the Calabazas Creek outfall (Figure 9) that a change in the creek's sediment transport behavior is not anticipated. Furthermore, the downstream reach of Calabazas Creek (Figure 10) is an earthen trapezoidal channel with floodwalls, prone to sediment aggradation rather than erosion.

Figure 9: Outfall to Calabazas Creek at Hwy 101

Figure 10: Downstream Reach of Calabazas Creek

2.3.5 *Additional Sources of Pollution*

A hydrology and water quality impact is considered significant if the plan would provide substantial additional sources of polluted runoff or otherwise substantially degrade surface or groundwater quality.

The conversion of industrial and commercial uses to high density residential uses is not considered to provide additional sources of polluted runoff, since vehicular trip generation should decrease and the amount of open space will actually slightly increase. Best Management Practices followed during and after construction may actually improve the water quality situation.

2.3.6 *Structures within a 100-year Flood Hazard Area*

> A hydrology and water quality impact is considered significant if the plan would place structures within a 100-year flood hazard area that impede or redirect flood flows.

Figure 11 superimposes flood hazards defined by the City of Sunnyvale FIRM, and the SCVWD's limits of flooding less than a foot deep over proposed land use designations. A Zone AO flood hazard represents moving water at relatively shallow depths (i.e. less than three feet). Blocking any part of the active flow conveyance path with a structure could increase the depth of flooding, either to the mapped Zone AO flooding or to the District's Shaded X flooding whereby either designated flood zone could potentially change. Zone AO (depth = 1.5 feet) could change to another designation (e.g. depth = 2 feet), or the Shaded X flooding could become Zone AO flooding (depths greater than one foot) requiring mandatory flood insurance for federally backed mortgages. While shallow overflows appear to be substantially blocked by existing buildings, with relatively little active flow conveyance, there is a chance that building reorientation during redevelopment could further reduce that active conveyance and change flood hazards as previously described. This impact cannot be addressed until actual site development plans are prepared. Section 3.3 describes potential measures to mitigate this potentially significant impact. The project area is not subject to tidal action.

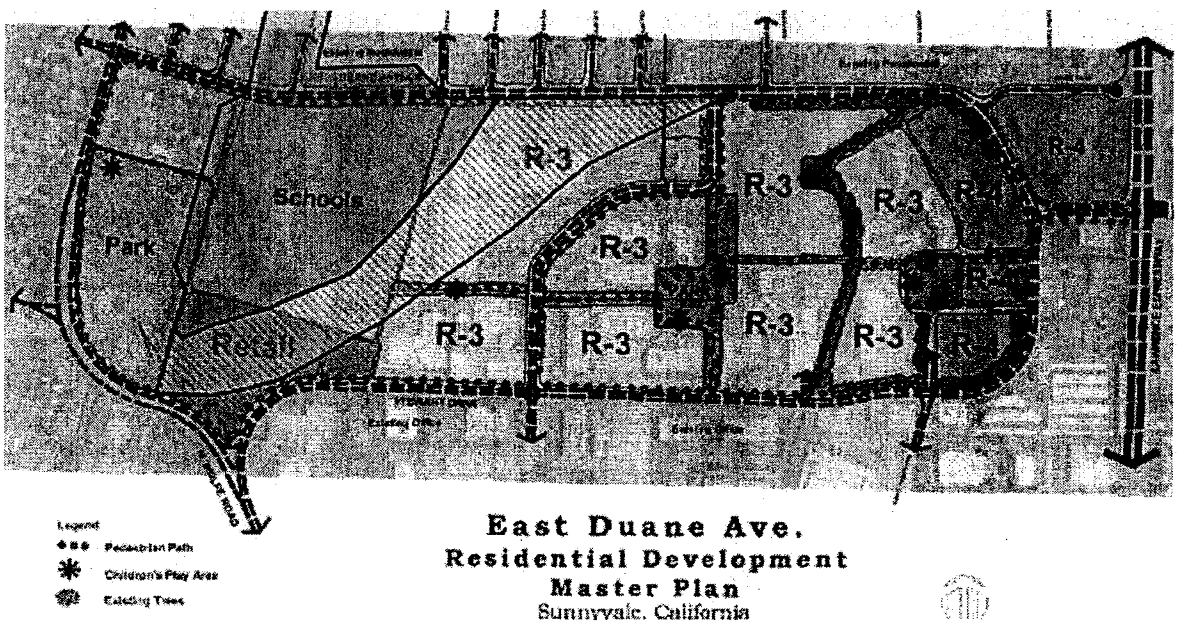


Figure 11: Flood Hazards Superimposed Over Proposed Land Use Plan
Solid Shading Indicates Zone AO (1.5 feet deep)
Hatched Shading Indicates Shaded Zone X (< 1 foot deep)

2.3.7 *People or Structures Exposed to Loss, Injury or Death*

> A hydrology and water quality impact is considered significant if the plan would expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam.

The risk of loss, injury, or death due to flooding from Sunnyvale East Channel overflows has been discussed previously. The area is protected from Calabazas Creek overflows by concrete floodwalls designed in accordance with National Flood Insurance Program criteria. These floodwalls provide at least three feet of freeboard above the estimated one-percent (100-year) base flood elevation. During an even more extreme event (with an annual risk of occurrence less than one percent), Calabazas Creek may not contain all of its discharge, exposing the project area to flooding. The floodwalls (a form of levee) could fail catastrophically, although this is a very unlikely scenario with a concrete wall. These risks are, however, considered acceptable in the context of national flood risk management standards. Fisher Creek and Coyote Creek would provide protection against 100-year flooding in conformance with all National Flood Insurance Program requirements. Nowhere in the Development Area would this flood protection rely upon an artificial levee or floodwall.

Dam inundation maps prepared for FERC (Schaaf & Wheeler, 1994-1995) indicate that the project area is not subject to inundation from a failure of Stevens Creek Dam nor Lexington Dam. Inundation from a catastrophic Stevens Creek Dam failure stops to the west at Wolfe Road, while possible inundation from a Lexington Dam failure stops to the east at Kiely Boulevard in Santa Clara.

2.3.8 *People or Structures Exposed to Seiche, Tsunami, or Mudflow*

> A hydrology and water quality impact is considered significant if the plan would expose people or structures to inundation by seiche, tsunami, or mudflow.

A seiche is the resonant oscillation of water in an enclosed body of water. For example if one were to sit in a bathtub partly filled with water and rock back and forth at the right period (about one second), the waves created will grow until they overflow the bath. Earthquakes and tsunamis (undersea earthquakes) can generate seiches in an enclosed body of water.

A tsunami is a series of waves formed in the sea as a result of a large-scale disturbance of sea level over a short period of time. In the process of sea level returning to equilibrium through a series of oscillations, waves are generated which propagate outward from the source region. A tsunami can be generated by submarine volcanic eruptions, by displacement of submarine sediments, by coastal landslides into a bay or harbor, by meteor impact, or by vertical displacement of the earth's crust along a zone of fracture which underlies or borders the ocean floor. The latter is the most frequent cause of tsunamis capable of propagating across an ocean.

The San Francisco County Office of Emergency Services and Homeland Security (2005) has mapped areas exposed to inundation by tsunami. Areas subject to inundation are limited to the western coast of San Francisco, and the tsunami threat does not extend to Baker Beach, let alone the Golden Gate or San Francisco Bay. Sunnyvale, therefore, is not threatened by tsunami.

3.0 Mitigation Measures

This section presents best management practices proposed for hydrology and water quality impact mitigation and environmental enhancement.[3]

3.1 *Best Management Practices for Water Quality*

While the impact of ITR land use conversion on urban runoff quality is not significant, best management practices can be utilized with new development to help treat urban runoff more effectively than at present. Runoff can be directed through permeable pavements and vegetated swales at the scale of individual developments; median strips and parkways at the neighborhood level, and treatment facilities described below to meet the NPDES C.3 Provisions at a plan level. Permanent BMP design features could include, but are not limited to, the following:

a. Dry Wells – Structured excavation filled with drain rock to collect stormwater and infiltrate it to subsurface soils.

b. Infiltration Basins – Shallow impoundments designed to collect and infiltrate stormwater into subsurface soils.

c. Infiltration Trenches – Long narrow trenches filled with permeable materials designed to collect and infiltrate stormwater into subsurface soils.

d. Permeable Pavements – Permeable hardscape that allows stormwater to pass through and infiltrate into subsurface soils.

e. Vegetated Filter Strips – Linear strips of vegetated surface designed to treat surface sheet flow from adjacent surfaces.

[3] City of Sunnyvale, *Interim Stormwater Quality BMP Guidance Manual: Stormwater Management Plan Preparation for New and Redevelopment Projects*, Volume 2, October 2003.

f. Vegetated Swales – Shallow open channels with vegetated sides and bottom designed to collect, slow, and treat stormwater as it is conveyed to downstream discharge point.

g. Flow-Through Planter Boxes – Structures designed to intercept rainfall and slowly drain it through filter media and out of planter.

h. Hydrodynamic Separator – Flow through structures with a settling or separation unit that removes sediments and other pollutants.

i. Media Filtration Devices – Two chamber system including a pretreatment settling basin and a filter bed.

j. Green Roofs – Vegetated roof systems that retain and filter stormwater prior to drainage off building rooftops.

k. Wet Vaults –Subsurface storage system designed to fill with stormwater during larger storm events and slowly release it into the conveyance system over a number of hours.

3.2 *NPDES Permit Requirements*

The Clean Water Act prohibits discharge of pollutants to waters in the United States unless the discharge complies with a National Pollutant Discharge Elimination (NPDES) permit. In California, the Regional Water Quality Control Boards administer the national NPDES program by issuing permits. Municipalities with a population greater than 100,000 or those that have been found to be significant polluters are classed as Phase I MS4s (municipal separate storm sewer systems), and must apply for an individual permit. (Smaller cities, community colleges, and so forth are classified as Phase II MS4s and have to show compliance with a general permit.) The City of Sunnyvale is a co-permittee in the Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPP), meaning that it shares an individual NPDES permit for discharging to the San Francisco Bay with the other 12 members of SCVURPPP.

As part of the permit requirements, SCVURPPP has a stormwater management plan including/addressing the following nine elements:

- program management
- illicit discharges
- industrial & commercial discharges
- new development and redevelopment, construction
- public agency(municipal) operations

- public information and participation
- program evaluation
- monitoring

3.2.1 ***C3 Provisions.*** In October 2001, the regional board changed the requirements for stormwater quality related to new development and redevelopment (Permit Provision C.3). Overall, the requirements of the C.3 provisions are to:

(1) implement water quality treatment; and

(2) ensure that flows and durations of stormwater runoff do not increase as a result of new development or redevelopment.

New development or redevelopment projects that must follow the C.3 provisions include:

- Commercial, industrial or residential developments that create one acre (43,560 square feet) or more of impervious surface including roof area, uncovered decks or porches, impervious paving and sidewalks.

- Any street, road, highway or freeway that is under the city's jurisdiction and that creates one acre or more of new impervious surface used for the transportation of motorized vehicles.

- Redevelopment of a site that was NOT previously subject to stormwater treatment measures AND results in one acre or more of impervious surface (including replacement of existing impervious surfaces).

The East Sunnyvale ITR project and individual developments therein clearly fall under the City's NPDES requirements for storm water treatment. According to the permit, if more than one half of the existing impervious surface is replaced, then the entire project must be included in the treatment measure design. Treatment Best Management Practices (BMPs) must be sized according to either volume design or flow design basis, depending on which is applicable to the selected BMP.

3.2.1.1 Volume Design Basis. Treatment BMPs whose primary mode of action depends on volume capacity, such as detention/retention units or infiltration structures, would be designed to treat stormwater runoff equal to:

a) The maximized stormwater quality capture volume for the area, based on historical rainfall records, determined using the formula and volume capture coefficients set forth in *Urban Runoff Quality Management, WEF Manual of Practice No. 23/ ASCE Manual of Practice No. 87, (1998)*, pages 175-178 (e.g., approximately the 85th percentile 24-hour storm runoff event); or

b) The volume of annual runoff required to achieve 80 percent or more capture, determined in accordance with the methodology set forth in Appendix D of the *California Stormwater Best Management Practices Handbook*, (1993), using local rainfall data.

An order of magnitude estimate for volume based water quality BMP has been made for the entire General Plan Amendment area, assuming an overall 80 percent impervious cover per City of Sunnyvale Planning Department restriction, by using the San Jose Capture Curve (for 48-hour drawdown) published in the California Stormwater BMP handbook (85^{th} percentile):

Impervious Area = (129 acres)(0.80) = 103 acres

The site is underlain by Castro Clay and Castro Silty Clay (both Soil Group D). The composite runoff coefficient from Table 1 is 0.75, and the volume calculation is:

For C = 0.75, 85^{th} percentile capture unit basin storage volume = 0.50 inch
For C =1.0, 85^{th} percentile capture unit basin storage volume = 0.65 inch

Required storage = (129 ac)(0.80)(0.50") = 4 acre-feet or
= (129 ac)(85%)(0.65") = 6 acre-feet

A preliminary required treatment volume size is 6 acre-feet (1 acre, 6 feet deep or 2 acres 3 feet deep). This volume needs to be "dead" storage located below any outlet with provisions to drain within 48 hours. It may be desirable, however, to drain such a facility more quickly due to concerns for adequate maintenance and vector control. This calculation results in a 0.6 acre-foot basin for the AMD site, when it is treated independently.

Infiltration options utilizing the percolation of water are subject to design criteria of a certain minimum distance to groundwater table and water supply wells.

3.2.1.2 Flow Design Basis. Treatment BMPs whose primary mode of action depends on flow capacity, such as swales, sand filters, or wetlands, would be sized during site design to treat:

a) 10% of the 50-year peak flow rate; or

b) the flow of runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity for the applicable area, based on historical records of hourly rainfall depths; or

c) the flow of runoff resulting from a rain event equal to at least 0.2 inches per hour intensity.

SCVURPPP allows the City to establish a waiver program that enables projects to substitute an 'Alternative Measure' in lieu of demonstrating compliance with the numeric sizing criteria for certain projects, including "Transit Oriented Projects". Alternative measures are only loosely defined, but generally refer to treating an equal amount of runoff or pollutant loading off-site (off-site treatment, stream restoration, etc.)

3.2.2 *Hydrograph Modification*

Flow management is also accomplished via the C.3 provisions through the implementation of a Hydrograph Modification Management Plan (HMP) which is based on a hydrologic analysis of the project area. Current guidelines for this provision indicate that pre-urbanized flow-duration curves must be matched using continuous rainfall simulation and a threshold discharge for erosion in receiving waters.

Per Permit Provision C.3.f.ii., projects located within areas that drain to stream channel segments that are unlikely to erode or experience impacts from increased flows (i.e. stable channel segments) are exempt from HMP requirements. As illustrated in Figure 12 (taken from the Final HMP Report), the reach of Calabazas Creek draining this part of Sunnyvale is exempt from HMP requirements.

3.2.3 *Stormwater Management During Construction*

Separate from the post-construction BMPs, any redevelopment project within Sunnyvale must comply with all requirements regarding State Water Resources Control Board's National Pollutant Discharge Elimination System (NPDES) General Construction Activities Permit. Therefore, prior to the commencement of any clearing, grading, or excavation, each project shall:

a) develop, implement, and maintain a Stormwater Pollution Prevention Plan (SWPPP) to control the discharge of stormwater pollutants including sediments associated with construction activities. The methods outlined in the SWPPP may include, but are not limited to protection of inlets, stabilized entrance to the site, straw waddles, and hydroseeding; and

b) file a Notice of Intent (N01) with the State Water Resources Control Board.

Along with NOI and SWPPP, the applicant may also be required to prepare an Erosion Control Plan in accordance with the requirements for the City Grading Permit. The Erosion Control Plan may include BMPs as specified in the California Stormwater Best Management Practice Handbook for reducing impacts on the City's storm drainage system from construction activities. The City's Director of Public Works must approve the Grading Permit, including the Erosion Control Plan.

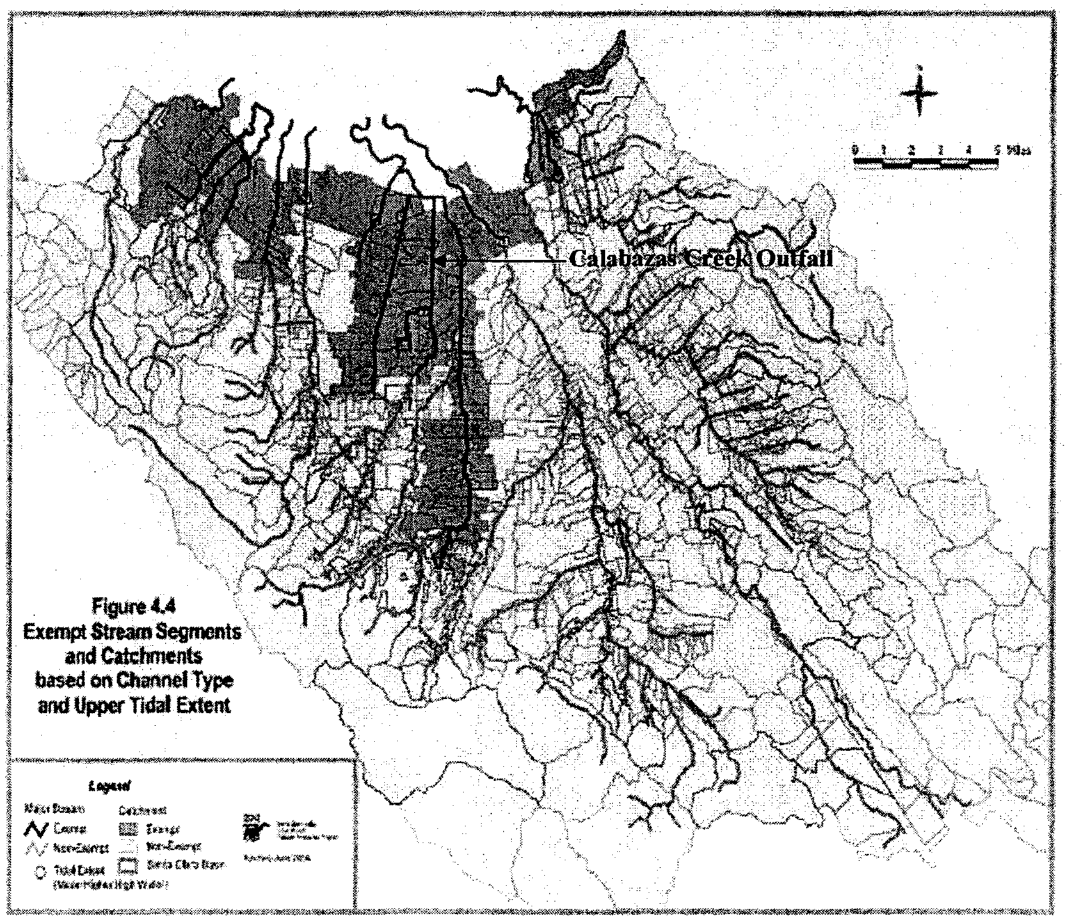


Figure 12: Stream Segments Exempt from HMP Requirements (SCVURPP)

3.3 *Mitigation of Flow Obstruction*

Section 2.3.6 identifies a potentially significant impact to local flood depths. At the time of site plan preparation, the rate of flow in the regulatory flood hazard zone can be calculated, with new structures oriented so as not to increase flood depths or patterns for the given rate of flow. Since the existing development pattern is dense, the likelihood of a non-mitigated impact is low.